Original Article

Changes in temporomandibular joint disc position and form following Herbst and fixed orthodontic treatment

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ABSTRACT

Objective: To determine the changes in the position and form of the temporomandibular joint articular disc in adolescents with Class II division 1 malocclusion and mandibular retrognathism treated with the Herbst appliance (phase I) and fixed orthodontic appliance (phase II).

Materials and Methods: Thirty-two consecutive adolescents went through phase I of treatment and 23 completed phase II. The temporomandibular joints were evaluated qualitatively by means of magnetic resonance images at the beginning of treatment (T1), during phase I (T2), at the end of phase I (T3), and at the end of phase II (T4).

Results: Significant changes in disc position were not observed with the mouth closed between T1 $\times$ T3 ($P = .317$), T3 $\times$ T4 ($P = .287$), or T1 $\times$ T4 ($P = .261$). At T2, on average, the disc was positioned regressively. With the mouth open, no difference was observed between T1 $\times$ T3 ($P = .223$) or T1 $\times$ T4 ($P = .082$). We did observe a significant difference between T3 $\times$ T4 ($P < .05$). Significant changes in the disc form were found with the mouth closed between T1 $\times$ T2 ($P < .001$) and T2 $\times$ T3 ($P < .001$).

Conclusions: At the end of the two-phase treatment, in general terms, the position and form of the initial articular discs were maintained; however, in some temporomandibular joints some seemingly adverse effects were observed at T4. (*Angle Orthod.* 2010;80:843–852.)

KEY WORDS: Temporomandibular joint; Magnetic resonance; Angle Class II malocclusion; Herbst therapy

INTRODUCTION

The use of orthopedic functional appliances to correct Class II malocclusions associated with retrognathic mandibles is indicated for the first phase of orthodontic treatment.[1–4] A second phase of treatment is undertaken with fixed orthodontic appliances to obtain occlusal refinement.[1,3] Among orthopedic appliances, the Herbst is commonly utilized as a means of maintaining the mandible in a constant anterior position.[1–3]

Although various investigations have shown[1–7] the efficiency of this method of treatment, the mechanism by which the temporomandibular joint (TMJ) responds to the treatment is controversial.[1–3,8] A recent study evaluated patterns of stress generation in the TMJ after mandibular protraction by using a three-dimensional finite element method.[9,10]

The relationship between temporomandibular disorders (TMDs) and orthodontic treatment has been the material for much debate. Some studies suggest that orthodontic treatment increases the risk of developing TMDs,[11,12] whereas two review studies[13,14] and the data from a meta-analysis[15] indicate that orthodontic treatment does not increase the prevalence of TMDs.

Taking into consideration that the internal derangement can involve, among other factors, changes in the position and form of the articular disc,[16] and because the magnetic resonance images (MRIs) permit direct visualization of the disc and the structures of the joint,[17–19] MRIs were chosen to supply diagnostic information on internal derangement of the TMJs.[20] The objective of this prospective study was to evaluate

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Accepted: December 2009. Submitted: September 2009.

possible changes in the position and form of the articular disc in the TMJs of adolescents with Class II division 1 malocclusion associated with mandibular retrognathism treated with the Herbst appliance (phase I) and fixed orthodontic appliance (phase II).

MATERIALS AND METHODS

Subjects

Thirty-two white Brazilian adolescents (16 boys and 16 girls) with Angle Class II division 1 malocclusion and mandibular retrognathism were selected consecutively for treatment. Mean pretreatment age of the subjects was 12.8 $\pm$ 1.2 year (range, 10.9 to 15.8 years). Selected characteristics of the patients are presented in Table 1. The Research Ethical Committee from the Federal University of São Paulo analyzed and approved the research project on June 12, 2000. All patients and guardians signed an informed consent form. Patients enrolled in the study showed the following characteristics:

- Clinical appearance of a retrognathic mandible, with an ANB angle greater than 4°
- Angle Class II division 1 malocclusion with a permanent dentition
- Maximum of skeletal pubertal growth peak[21]
- Joints where the disc was positioned within standard norms or joints with disc displacement (DD).

Treatment was divided into two phases. The first phase lasted 12 months and consisted of treatment with a modified Herbst appliance[1] (metal crowns, bands, upper Hyrax expander, and lower lingual arch). Rapid expansion of the maxilla took place during the first 2 weeks after Herbst appliance placement.[1]

Up to 6 mm mandibular advances were carried out at the beginning of the treatment. When necessary, 2–3 mm complementary advances were performed in the third month.[1] Immediately after concluding phase I, 23 of the 32 adolescents (13 boys and 10 girls) continued treatment with a fixed orthodontic appliance (phase II) with preadjusted 0.022 $\times$ 0.028 in. brackets. The average time for phase II was 2.2 $\pm$ 0.9 years.

METHODS

MRIs of the right and left TMJs with mouth closed (MC) and mouth opened (MO) were taken at four time points during treatment: immediately before the beginning of phase I of treatment (T1), 8 to 10 weeks after Herbst appliance placement (T2), at the end of phase I of treatment (T3), and immediately after the conclusion of phase II treatment with a fixed orthodontic appliance (T4). The MRI protocol was described in a previous study.[1]

The MRIs were interpreted visually by two different observers who underwent previous training to use the same protocol. The position and form of the articular discs (biconcave and non-biconcave when there was an increase or deformity of the bands of the disc) were evaluated in parasagittal images (MC and MO).[22,23] Images taken in the coronal plane were used to avoid false-negative findings during DD in a lateromedial direction.[23]

Statistical Methods

Evaluations of intraobserver and interobserver differences were performed in accord with Franco et al.[4] A kappa of less than 0.4 was considered poor and a kappa greater than 0.75 was considered excellent.

The nonparametric Kappa and McNemar tests were applied at the 5% level of significance to evaluate the concordance between the left and right TMJs and the changes due to treatment in relation to the previously defined positions (MC and MO) at T1, T2, T3, and T4.

RESULTS

The assessment of intraobserver variability related to measurements of the form of the articular disc yielded $\kappa = 0.44$ for reading 1 vs 2 and $\kappa = 0.57$ for reading 2 vs 3. The evaluation of the articular disc position showed $\kappa > 0.75$ for reading 1 vs 2 and reading 2 vs 3, with $\kappa = 0.80$ and $\kappa = 0.93$, respectively. Interobserver Kappa (observer A's reading 3 vs observer B's reading) with regard to disc form ($\kappa = 0.79$) and position ($\kappa = 0.91$) showed excellent agreement.

Disc Position

In 42 joints (65.6% MC) the disc was in a superior position (T1, T3). At T2, the disc tended toward a retrusive position in relation to the condyle. In the MO position, the disc was interposed between the condyle and the articular eminence (T1, T2, and T3).

In 22 joints (34.4% MC) where the discs were displaced at T1, there was recapture or partial recapture of the discs at T2, and they returned to their original position at T3. In the MO position, the disc was recaptured in most cases (T1, T2, T3).

For T3–T4 (MC) there were changes in five joints (cases 1 and 11 with left and right TMJs; case 23 with right TMJ). For T3–T4 (MO) there were changes in four joints (cases 1 and 11 with left and right TMJs; Table 2).

Disc Form

For T1–T3 there were no changes (63 TMJs MC, 98.4%; 61 TMJs MO, 95.3%). Changes were observed in four TMJs (case 11, MC, left TMJ; case 19, MO, left

Table 1. Characteristics of the patients at the beginning of treatment[a]

			Class II Molar Relationship			Björk and Helm[21] Stages
Cases	Gender	T1 (y)	Right Side	Left Side	Overjet (mm)	Hand and Wrist X-rays
1	Female	11.9	3/4	1/2	7	S
2	Female	12.9	3/4	1/2	6	MP_3cap
3	Male	14.5	∧	∧	9	MP_3cap
4	Female	12.4	∧	∧	9.5	MP_3cap
5	Female	11.7	3/4	∧	10	S
6	Female	11.1	3/4	∧	11	S
7	Female	11	∧	3/4	13	S
8	Male	14.1	3/4	1/2	6	MP_3cap
9	Male	12.7	∧	∧	8	S
10	Female	11.4	3/4	3/4	12	MP_3cap
11	Female	11.7	3/4	∧	7	MP_3cap
12	Female	11.9	3/4	3/4	12	MP_3cap
13	Female	13.7	3/4	1/2	12	MP_3cap
14	Male	13.7	3/4	3/4	7	MP_3cap
15	Male	12.3	∧	1/2	11	S
16	Female	13.3	3/4	3/4	9	MP_3cap
17	Male	14.1	3/4	∧	10	S
18	Male	11.7	∧	1/2	7	MP_3cap
19	Male	13.6	1/2	1/2	7	MP_3cap
20	Male	13.1	3/4	3/4	7	S
21	Female	12.3	1/2	1/2	6	MP_3cap
22	Female	12.1	1/2	3/4	9	MP_3cap
23	Male	13	3/4	1/2	8	MP_3cap
24	Female	12.4	∧	∧	8	MP_3cap
25	Female	11.5	1/2	1/2	6	MP_3cap
26	Male	13.7	∧	∧	11	MP_3cap
27	Male	13.7	∧	3/4	8	S
28	Male	14	1/2	∧	7	MP_3cap
29	Male	13.1	1/2	3/4	10	S
30	Male	13.8	1/2	1/2	5	MP_3cap
31	Male	15.8	3/4	∧	9	MP_3cap
32	Female	12	∧	3/4	8	S

[a] ∧ indicates full Class II; S, Björk and Helm[21] third stage; MP_3cap, Björk and Helm[21] fourth stage.

and right TMJs; case 26, MO, right TMJ). The discs that showed non-biconcave shape (MC) in T1, on average, turned biconcave in T2 and returned to their original shape in T3. For T3–T4 there were changes in four joints (case 5 [MC] and case 29 [MO], left and right TMJs; see Table 3).

Once substantial agreement was observed when comparing the left and right TMJs (Table 4), they were pooled. The results of the changes due to the treatment are presented in Table 5.

DISCUSSION

As a result of the mandibular advance and expansion of the maxilla determined by the use of Herbst appliance associated to a Hyrax expander, sagittal, transverse, and vertical changes took place.[1] In this way the equilibrium of the stomatognathic system can be jeopardized, thus increasing the risk of developing TMDs.[11,12]

For this reason, we carried out a prospective study where we evaluated longitudinally the position and form of the articular disc of the TMJs, with MC and MO, during the whole treatment (T1–T4; Figures 1 and 2). The relative clinical evaluations will be presented in a future article.

The normal position of the posterior band of the disc in relation to the condyle is 12 o'clock[22] in the MC position, although other investigations have noted variations in the position of the disc among asymptomatic populations.[22,24] Different metric procedures for analyzing the sagittal disc position have been proposed because the 12 o'clock method for determining disc position relative to the condyle has led to misinterpretation. However, there is consensus that normal variations occur in physiologic positions, and disc position might be described differently depending on the reference lines used.[2] In our study, the posterior band of the disc was classified as being in a normal position when it was situated between 11 and 1 o'clock.[3] This allowed for physiologic variation.

Aside from the position of the disc, alterations in the form of the disc are involved in internal derangement of the TMJs.[16] MRIs have proven themselves to be

Table 2. Articular disc position at T1, T2, T3, and T4[a]

	T1				T2				T3				T4			
	Left TMJ		Right TMJ		Left TMJ		Right TMJ		Left TMJ		Right TMJ		Left TMJ		Right TMJ	
Cases	MC	MO	MC	MO	MC	MO	MC	MO	MC	MO	MC	MO	MC	MO	MC	MO
1	NL	I	NL	I	RP	I	RP	I	NL	I	NL	I	ADD	DDWR	AMDD	DDWR
2	NL	I	NL	I	RP	I	RP	I	NL	I	NL	I	NL	I	NL	I
3	NL	I	NL	I	RP	I	RP	I	NL	I	NL	I	NL	I	NL	I
4	LDD	I	NL	I	RP	I	RP	I	LDD	I	NL	I	LDD	I	NL	I
5	MDD	I	MDD	I	RP	I	RP	I	MDD	I	MDD	I	MDD	I	MDD	I
6	NL	I	NL	I	RP	I	RP	I	NL	I	NL	I	NL	I	NL	I
7	NL	I	NL	I	RP	I	RP	I	NL	I	NL	I	NL	I	NL	I
8	MDD	I	NL	I	RP	I	RP	I	MDD	I	NL	I	MDD	I	NL	I
9	NL	I	NL	I	RP	I	RP	I	NL	I	NL	I	NL	I	NL	I
10	AMDD	DDWR	AMDD	DDWR	Recap	DDWR	Recap	DDWR	AMDD	DDWR	AMDD	DDWR				
11	NL	I	ALDD	DDWR	RP	I	Recap	DDWR	NL	I	LDD	I	ADD	DDWR	ALDD	DDWR
12	NL	I	NL	I	RP	I	RP	I	NL	I	NL	I				
13	ALDD	DDWR	ADD	DDWR	Recap	DDWR	P Recap	DDWR	ALDD	DDWR	ADD	DDWR				
14	NL	I	NL	I	RP	I	RP	I	NL	I	NL	I	NL	I	NL	I
15	NL	I	NL	I	RP	I	RP	I	NL	I	NL	I				
16	NL	I	NL	I	RP	I	RP	I	NL	I	NL	I				
17	NL	I	NL	I	RP	I	RP	I	NL	I	NL	I				
18	NL	I	NL	I	RP	I	RP	I	NL	I	NL	I	NL	I	NL	I
19	ALDD	DDWPR	ALDD	DDWPR	Recap	DDWR	Recap	DDWR	ALDD	DDWR	ALDD	DDWR	ALDD	DDWR	ALDD	DDWR
20	NL	I	NL	I	RP	I	RP	I	NL	I	NL	I	NL	I	NL	I
21	ALDD	DDWR	NL	I	Recap	DDWR	RP	I	ALDD	DDWR	NL	I	ALDD	DDWR	NL	I
22	NL	I	NL	I	RP	I	RP	I	NL	I	NL	I				
23	NL	I	NL	I	RP	I	RP	I	NL	I	NL	I	NL	I	LDD	I
24	NL	I	NL	I	RP	I	RP	I	NL	I	NL	I				
25	MDD	I	MDD	I	RP	I	RP	I	MDD	I	MDD	I	MDD	I	MDD	I
26	ALDD	DDWR	AMDD	DDWPR	Recap	DDWR	P Recap	DDWR	ALDD	DDWR	AMDD	DDWPR	ALDD	DDWR	AMDD	DDWPR
27	AMDD	DDWR	AMDD	DDWR	Recap	DDWR	Recap	DDWR	AMDD	DDWR	AMDD	DDWR	AMDD	DDWR	AMDD	DDWR
28	ADD	DDWR	AMDD	DDWR	Recap	DDWR	P Recap	DDWR	ADD	DDWR	AMDD	DDWR	ADD	DDWR	AMDD	DDWR
29	ADD	DDWR	AMDD	DDWR	Recap	DDWR	Recap	DDWR	ADD	DDWR	AMDD	DDWR	ADD	DDWR	AMDD	DDWR
30	NL	I	NL	I	RP	I	RP	I	NL	I	NL	I				
31	NL	I	NL	I	RP	I	RP	I	NL	I	NL	I	NL	I	NL	I
32	NL	I	NL	I	RP	I	RP	I	NL	I	NL	I	NL	I	NL	I

[a] TMJ indicates temperomandibular joint; MC, mouth closed; MO, mouth open; NL, normal; ADD, anterior disc displacement ; AMDD, anteromedial disc displacement; ALDD, anterolateral disc displacement; MDD, medial disc displacement; LDD, lateral disc displacement; I, interposed; DDWR, disc displacement with reduction ; DDWPR, disc displacement with partial reduction; RP, retrusive position; Recap, recaptured; P Recap, partially recaptured.

Table 3. Articular disc form at T1,T2, T3, and T4[a]

	T1				T2				T3				T4			
	Left TMJ		Right TMJ		Left TMJ		Right TMJ		Left TMJ		Right TMJ		Left TMJ		Right TMJ	
Cases	MC	MO	MC	MO	MC	MO	MC	MO	MC	MO	MC	MO	MC	MO	MC	MO
1	NB	B	NB	B	B	B	B	B	NB	B	NB	B	NB	B	NB	B
2	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B
3	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B
4	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B
5	B	B	B	B	B	B	B	B	B	B	B	B	NB	B	NB	B
6	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B
7	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B
8	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B
9	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B
10	NB	B	NB	B	NB	B	NB	B	NB	B	NB	B				
11	B	B	NB	B	B	B	B	B	NB	B	NB	B	NB	B	NB	B
12	B	B	B	B	B	B	B	B	B	B	B	B				
13	NB	B	NB	B	B	B	NB	B	NB	B	NB	B				
14	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B
15	B	B	B	B	B	B	B	B	B	B	B	B				
16	B	B	B	B	B	B	B	B	B	B	B	B				
17	B	B	B	B	B	B	B	B	B	B	B	B				
18	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B
19	NB	NB	NB	NB	B	B	B	B	NB	B	NB	B	NB	B	NB	B
20	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B
21	NB	B	B	B	B	B	B	B	NB	B	B	B	NB	B	B	B
22	B	B	B	B	B	B	B	B	B	B	B	B				
23	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B
24	B	B	B	B	B	B	B	B	B	B	B	B				
25	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B
26	NB	B	NB	NB	B	B	NB	B	NB	B	NB	B	NB	B	NB	B
27	NB	B	NB	B	NB	B	NB	B	NB	B	NB	B	NB	B	NB	B
28	NB	B	NB	B	B	B	NB	B	NB	B	NB	B	NB	B	NB	B
29	NB	B	NB	B	B	B	B	B	NB	B	NB	B	NB	NB	NB	NB
30	B	B	B	B	B	B	B	B	B	B	B	B				
31	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B
32	NB	B	NB	B	B	B	B	B	NB	B	NB	B	NB	B	NB	B

[a] TMJ indicates temperomandibular joint; MC, mouth closed; MO, mouth open; B, biconcave; NB, non-biconcave.

Table 4. Evaluation of the position and form of the temporomandibular joint disc, between left and right temporomandibular joint, with mouth closed (MC) and mouth open (MO) at T1, T2, T3, and T4

	Kappa		
	κ	P	Concordance (%)
Disc Position			
MC - T1	–		75.1
MO - T1	0.762	**	90.6
MC - T2	–		84.4
MO - T2	0.833	**	93.8
MC - T3	0.544	**	75.1
MO - T3	–		93.8
MC - T4	–		60.8
MO - T4	–		91.3
Disc Form			
MC - T1	0.855	**	93.7
MO - T1	0.652	**	96.9
MC - T2	0.529	**	90.7
MO - T2	1.000	**	100.0
MC - T3	0.929	**	96.9
MO - T3	1.000	**	100.0
MC - T4	0.911	**	95.6
MO - T4	1.000	**	100.0

** $P < .001$.

Table 5. Evaluation of the changes on the position and form of the temporomandibular joint disc, with mouth closed (MC) and mouth open (MO), among T1, T2, T3, and T4

	McNemar	Concordance
	(P)	(%)
Disc Position		
MC - T1 × T3	.317	98.40
MC - T3 × T4	.287	89.20
MC - T1 × T4	.261	91.40
MO - T1 × T2	–	95.30
MO - T2 × T3	–	96.90
MO - T3 × T4	.046*	91.30
MO - T1 × T3	.223	95.40
MO - T1 × T4	.082	89.20
Disc Form		
MC - T1 × T2	**	79.70
MC - T2 × T3	**	78.10
MC - T3 × T4	.5	95.70
MC - T1 × T3	1	98.50
MC - T1 × T4	.25	93.50
MO - T1 × T2	–	95.30
MO - T2 × T3	–	100.00
MO - T3 × T4	–	95.70
MO - T1 × T3	–	95.30
MO - T1 × T4	1	89.10

* $P < .05$; ** $P < .001$

extremely accurate when evaluating the form of the disc.[24] Thus, it is important to detect possible alterations in the form of the disc as a result of treatment with the Herbst appliance, due to compression of the condyle and articular disc against the articular eminence.[25]

The results showed that significant changes in the position of the disc did not occur with MC ($P = .317$) and MO ($P = .223$) between T1 and T3. At T1, in the MC position, the disc was in a superior position in 42 joints (65.6%), and no changes were observed in T3. Our findings were in agreement with previous investigations.[2,3] In contrast to our results, Foucart et al.,[8] in a sample of ten Herbst subjects found three patients who showed varying degrees of DD in one or both joints evaluated by means of MRI.

In 22 joints (34.4%), where the discs were displaced at T1, these discs were typically recaptured at T2 and returned to their original position at T3. Only case 11 (right TMJ) presented anterolateral disc displacement (ALDD) at T1 and became lateral DD at T3, although the disc remained displaced. In agreement with our results Ruf and Pancherz[3] observed that, in the case of total DD with reduction (DDWR), only a temporary repositioning of the disc could be obtained during the Herbst treatment.

When comparing T1 × T2 and T2 × T3, significant changes were encountered with MC, ($P < .001$) in the form of TMJ discs that showed DD at T1 with a non-biconcave form. At T2, on average, the discs were repositioned as a result of mandible advancement induced by the Herbst appliance. These discs assumed a biconcave form. However, at T3 the position and form of the disc returned to their pretreatment state.

In the present study there were no significant alterations in the form of the articular disc, with MC ($P = 1.000$) and MO (concordance, 95.3%) from T1 to T3. In one joint (case 11, left TMJ), the form of the disc worsened at T3 with MC. In three joints (case 19, left and right TMJs; case 26, right TMJ), the form of the disc at T3 improved with MO but remained displaced with MC. Our findings are similar to the results published by Franco et al.,[4] despite the fact that different methodologies were used.

Although they used a different methodology than we did, Ruf and Pancherz[3] evaluated the TMJs at three stages: before, immediately after, and 1 year after treatment with the Herbst appliance (in some cases, patients were still being treated with a fixed appliance). The authors did not find adverse effects in the TMJs evaluated over this short time. In our study, the final evaluation (T4) occurred immediately after treatment was finished in all patients. Thus, after 27 months of T3, our results showed that there were no significant alterations in the position of the disc with MC ($P = .287$) when T3 and T4 were compared. On the other hand, we found changes in five joints (cases 1 and 11, left and right TMJs; case 23, right TMJ). The right TMJ of case 11, which already presented ALDD at T1, became lateral DD at T3 and returned to ALDD at T4.

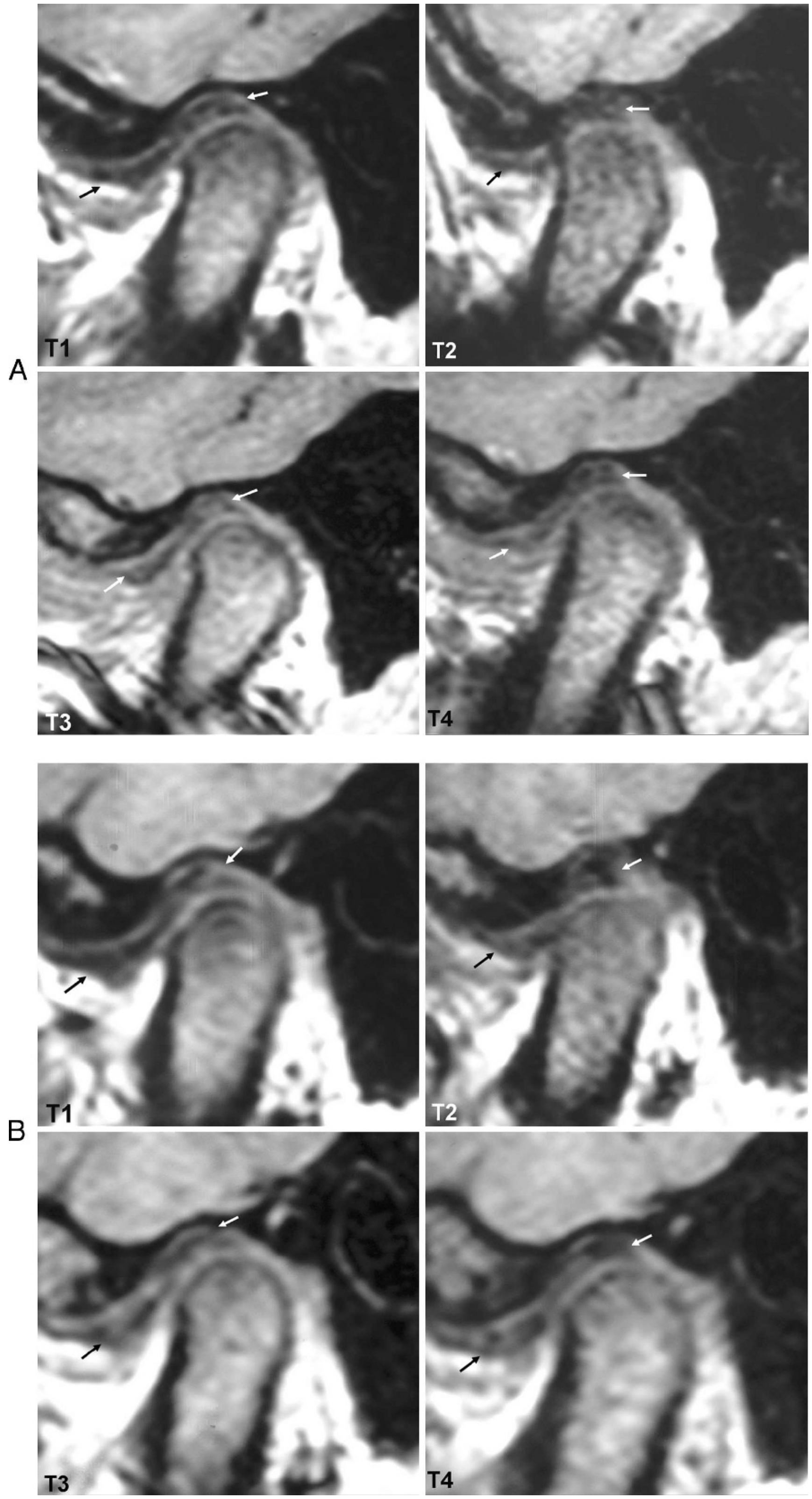

Figure 1. Case 9. Left (A) and right (B) temporomandibular joint magnetic resonance images (mouth closed). The disc is in its normal superior position at T1, T3, and T4, showing a retrusive tendency at T2. The disc form is biconcave.

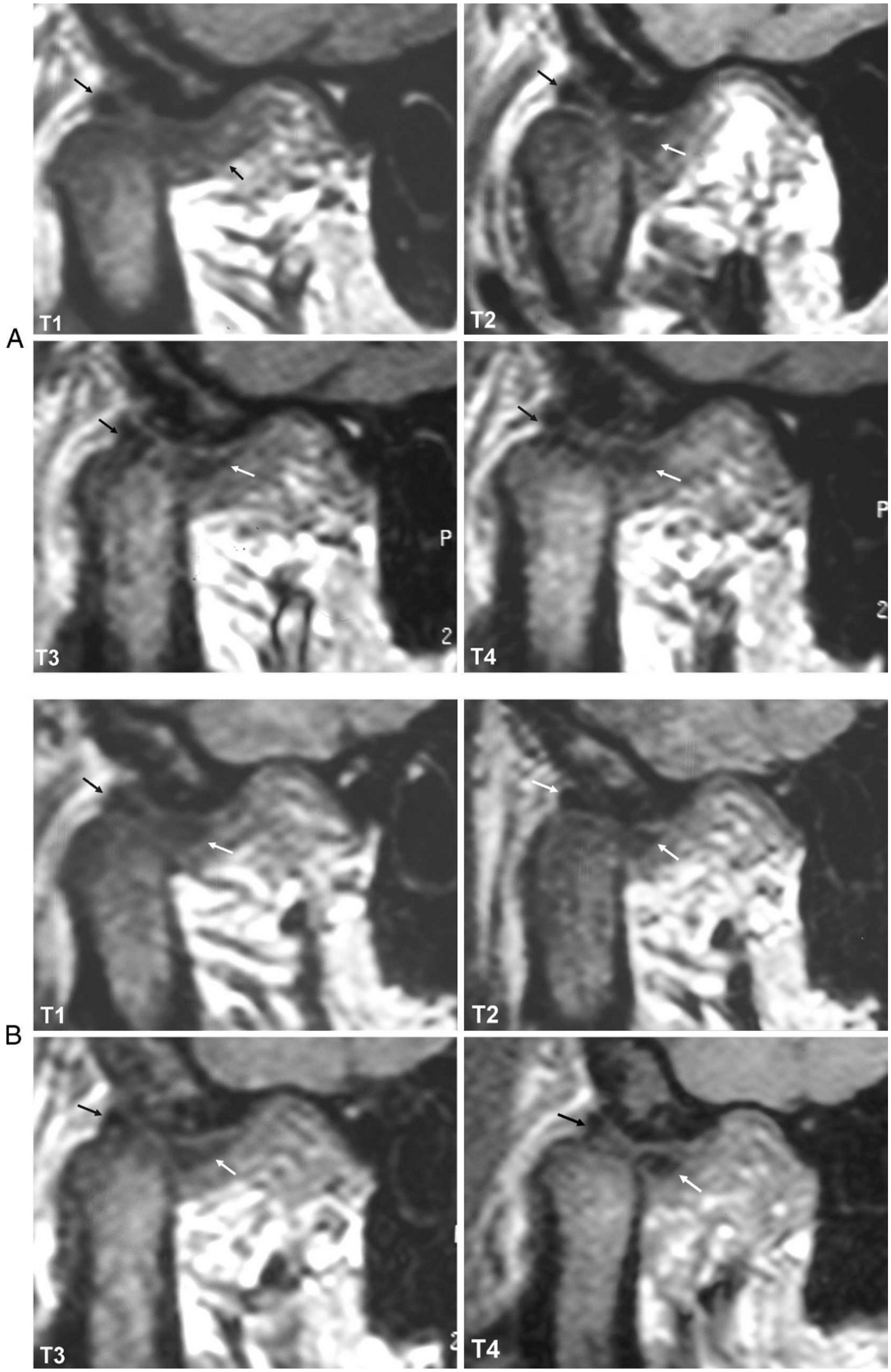

Figure 2. Case # 9. Left (A) and right (B) temporomandibular joint magnetic resonance images (mouth open). The disc was interposed between the condyle and the articular eminence. The disc form is biconcave.

The other four TMJs presented DD at T4, although these same TMJs presented disc position within normal standards at T1 and T3.

Based on scientific evidence, we know that alterations in the form of the disc can be involved in internal derangement of the TMJs[16] (case 1, left and right TMJs; case 11, left TMJ). In the same way, the presence of DD in the counterlateral joint (case 11, right TMJ) could increase the frequency of occurrence of DD in another joint by up to 60%[26] (case 11, left TMJ). It is difficult to know if the worsening of the function of these joints predisposed them to the development of DD or if the treatment interfered in this process. In case 23 (right TMJ), we could not establish the cause-effect relationship of the observed change.

In four other joints (cases 5 and 29, left and right TMJs) the disc was already displaced at T1 and remained so at T3 and T4. However, the form of the disc changed from biconcave to non-biconcave at T4 (case 5 with MC and case 29 with MO). One can speculate that in these two cases, the DD present at T1 may have caused the modifications to the disc at T4. Only by means of a longitudinal follow-up of these TMJs will it be possible to evaluate the impact of these changes and their evolution.

In the MO position, comparing T3 and T4 ($P < .05$), we observed changes in four joints (cases 1 and 11, left and right TMJs). The classification of the position of the disc changed from interposed (I) to DDWR, because the TMJs presented DD with MC at T4. Although the classification may have changed, the disc was interposed between the condyle and the articular eminence in both situations.

When considering the total period of the evaluation (T1–T4), there was no significant change in the position (MC, $P = .261$; MO, $P = .082$) or in the form (MC, $P = .250$; MO, $P = 1.000$) of the articular disc. Contrary to Ruf and Pancherz,[3] in our study, the joints that presented DDWR with MO at T1 did not progress to DD with no reduction at T4.

Contrary to current concepts affirming that occlusion is not a primary factor in the multifactorial nature of the TMDs,[27] some occlusal factors, such as severe overjet[28] and distal molar occlusion,[29] are associated with signs and symptoms of TMD. This would suggest that individuals with Class II malocclusion have more risk of developing TMDs.[3]

In our study, in all of the patients that finished treatment with the fixed orthodontic appliance (T4) our treatment objective was always to obtain a stable occlusion within gnathological principles, seeking to minimize the local factors that could collaborate in the development of TMDs. However, sporadic alterations at T4 in the position and form of the articular disc can be observed. This fact emphasizes the importance of a thorough evaluation of the patients to be treated so that eventual alterations that may occur as a result of treatment may be justified.

CONCLUSIONS

- At the end of the two-phase treatment, in general terms, the position and form of the initial articular discs were maintained; however, at the end of phase II (T4) changes observed may be associated with the possibility of future problems.

ACKNOWLEDGMENTS

Many thanks to Dr Rejane Faria Ribeiro-Rotta for helping with the interpretation of the MRIs and to Dr Peter Taylor for the translation of this manuscript.

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